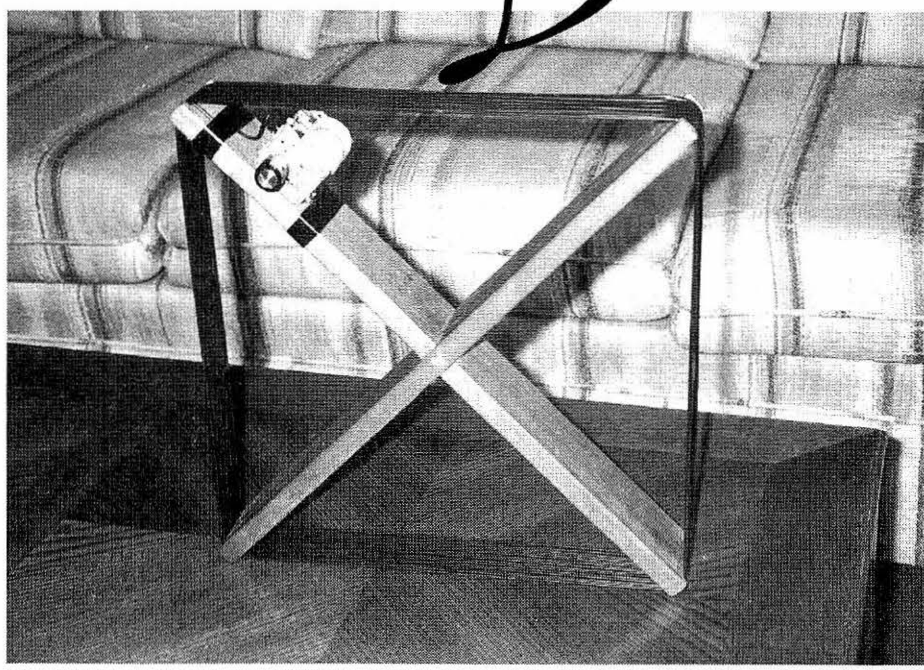
Get in the Mediumwave Loop

A loop antenna overcomes many of the disadvantages of the random-length antenna, says the author. Here's a step-by-step approach to building a very capable mediumwave antenna that won't make the neighbors angry.



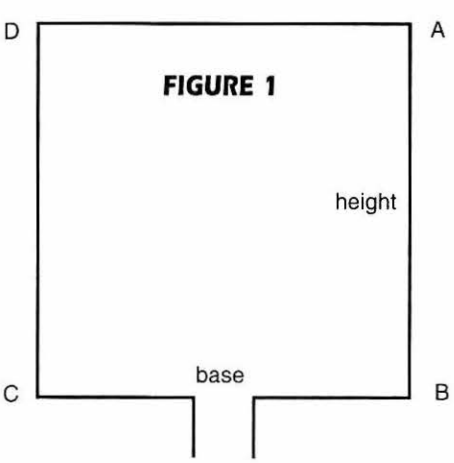
Building an effective mediumwave loop is not as hard as you might think. Read on for detailed description.

By Philip Gebhardt, VA3ACK

Getting started in mediumwave (MW) DXing is easy. You grab a length of wire, connect an insulator to one end, attach it to a tree and then connect the other end to your receiver. However, almost every MW DXer eventually trades the random-length antenna for a loop antenna. As on any band, the right antenna is the key to success. But getting the most from your loop antenna means understanding how it works.

A loop antenna overcomes the disadvantages of a random-length antenna. Loops can be made very small, whereas a random-length antenna needs to be at least 75-feet long. And although loops have a fixed antenna pattern (so do random-length wires), you can rotate a loop so it points toward the desired station. (It's pretty tough to rotate a 75-foot length of wire.) Alternatively, you can point a loop away from an interfering station. Unlike a wire antenna, a loop doesn't need an antenna tuner or a good ground connection.

Using a simple MW receiving loop, you can hear hundreds of stations throughout the U.S., Canada, the Caribbean, Central America, and South America. Some, like WSB in Atlanta, can be heard almost every night; others, like Deutsche Welle's Caribbean relay station on 930 kHz in Antigua, may take a little work.



A square loop viewed from the side. AB = CD = the height of the loop; AD = BC = the base of the loop. Sides AB and CD are vertical; sides AD and BC are horizontal.

Using a simple loop antenna built on a cardboard box, I was able to hear WBMQ (630 kHz with 5 kW) in Savannah, Georgia, from Nassau, Bahamas, at noon. (The 540 km path is almost entirely over salt water.) Late one night (between sunset and sunrise is when most MW DX can be heard), I heard CBL in Toronto, Ontario, (740 kHz with 50 kW) from the same location using the same cardboard box loop.

Loops come in all shapes and sizes. (Not many are built on cardboard boxes, though!) Each has advantages and disadvantages. The main disadvantage of commercially-manufactured loops is the cost. The alternative is to build your own.

Loops can be circular, octagonal, heptagonal, hexagonal, pentagonal, quadrilateral, or triangular. Mechanically, the circular loop is the most difficult to build, mount, and rotate. The octagonal loop is a modification of the circular loop which enables the builder to use straight sections rather than a curve.

The rectangular loop is mechanically simple since its frame is nothing but a single pair of diagonal supports. If you're building or analyzing loop operation, it's the one to start with.

The first design question is: Should such a loop have a long base and short height or a short base and long height? Or, does it matter? Mathematically, a square loop is the best choice. Conveniently, a square loop is the easiest to build and to analyze. The concepts can then be applied to other shapes.

Figure 1 shows a one-turn, square loop antenna. All MW broadcast stations transmit vertically polarized signals (that is, the electric field is vertical and the magnetic field is horizontal). As a vertically-polarized signal passes vertical side AB, a voltage is induced in the wire. Later, when the signal passes vertical side CD, a voltage is induced in that wire.

However, no voltage is induced in the horizontal sides AD and BC.

The total voltage generated in the loop is the difference between the voltages in sides AB and CD. Figure 2 shows how this happens.

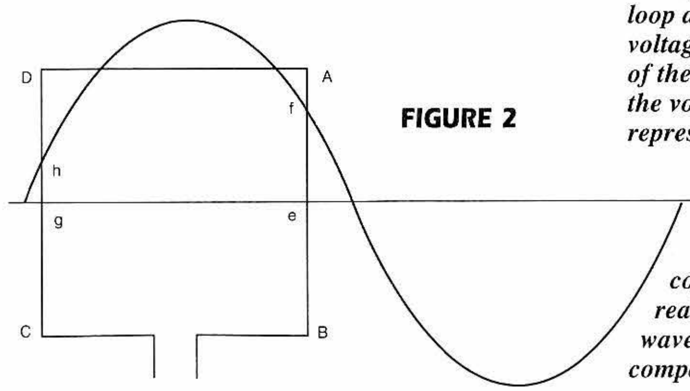


FIGURE 2

At any instant, as a signal travels past a loop antenna, it generates a different voltage in the two vertical wires because of the width of the loop. In loop ABCD, the voltage induced in side CD is represented here by the value "gh" while the voltage induced in side AB is shown by the value "ef." Note that for clarity the loop is deliberately drawn large in comparison to one wavelength. A real loop with a perimeter of 0.08 wavelength would be very small compared to one wavelength.

FIGURE 3

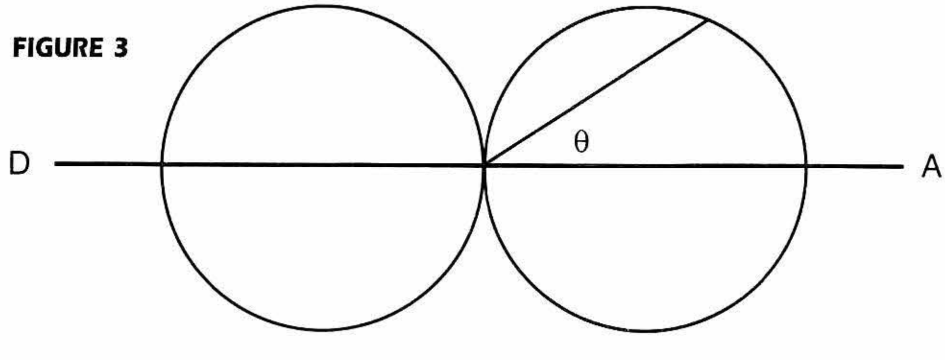


FIGURE 3—*The antenna pattern forms a figure 8. The signal induced in the loop is maximum when the antenna is pointed at the station. This occurs when cosq = 1 (that is, when q = 0°). Maximum signal is induced therefore when points A and D of the loop in Figure 1 and the transmitter are in-line. Nulls occur when the station is broadside to the loop.*

FIGURE 4—*A multi-turn loop antenna with n turns will act like n loops connected together. The frame can be a box form (a) or a pancake form (b). In a box form, the loops are all the same size, but they are not coplanar; in a pancake form, the loops are coplanar, but each one is a different size.*

A signal from a station off the side of the loop (in a direction perpendicular to base BC) reaches sides AB and CD simultaneously. It therefore generates equal voltages in the wires. The two voltages cancel and no signal is heard.

In addition, the loop is bidirectional. That is, the signal could pass through side CD first and then through side AB later. Similarly, the loop nulls signals from either direction perpendicular to the plane of the loop. Therefore, a loop which is pointed north will receive signals from stations to the north and south while signals from eastern and western stations will be nulled.

This produces the classic figure 8 pattern shown in Figure 3. When the loop is neither pointed at a station nor is broadside to the station, the signal induced in the loop is intermediate between the maximum value and zero.

This then gives rise to a major value of the loop antenna: You can point it at a desired station or orient it to null out an interfering station. Keep in mind that you can't necessarily do both at the same time.

The basic multi-turn loop

So far, the loop has a single turn. In an effort to decrease the overall size (a MW loop will have sides about 21-feet long), smaller, multi-turn antennas have been developed. These antennas are configured as a box or as a pancake. (See Figure 4.)

The loops described until now have been non-resonant loops. In practice, a variable capacitor is connected in series with the loop to tune it to resonance.

With no more information than this, you can successfully build and use a loop antenna such as the one described here. Cut the two diagonal, wooden supports approximately 17-inches long. I use pieces of 1-inch by 4-inch lumber. (See Figure 5.) These produce a square with 1-foot sides and a 4-foot perimeter. An 84-foot length of magnet wire will therefore give a 24-turn antenna. (Loops use a maximum of 0.08 wavelength of wire. At 940 kHz, 84-feet is about 0.08 wavelength. This length allows a 365-pF variable capacitor to tune the entire broadcast band.) The two free ends of the wire are connected across the 365-pF variable capacitor. This completes the antenna construction.

In practice, I space the turns 1/8-inch apart. I also notch the ends of the support so the wire cannot move sideways. The most convenient location to mount the capacitor is on one of the diagonal supports.

Using this antenna is equally simple. Any receiver with a built-in ferrite loopstick antenna is suitable. Tune your receiver to a distant, weak station. Now place the loop antenna next to the receiver with the loop pointed toward the station. Place the receiver next to side AB of the loop antenna, but positioned so the receiver is broadside to the station. In this position, the loop antenna and the receiver's built-in ferrite loopstick are coupled together.

The signal can be peaked by tuning the capacitor. You may need to re-aim the loop to get maximum signal. From my listening post near Toronto, Ontario, I cannot hear CJBQ in Belleville (100 air miles to the east) without the loop. Using the loop, the 10 kW broadcaster sounds like a local station.

An easy method of rotating the antenna (while keeping it perpendicular to the

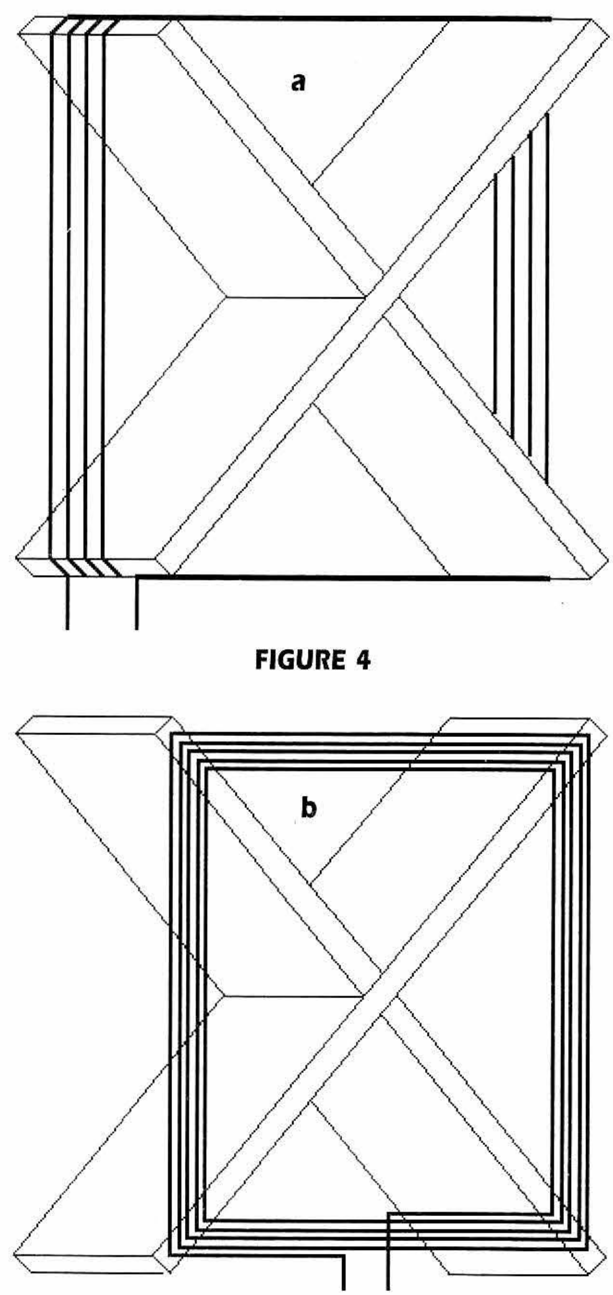


FIGURE 4

receiver) is to place both the antenna and the receiver on a rotatable, lazy Susan tray.

To avoid frustration, it is necessary to be aware of the limitations of loop antennas. A home-made loop is rarely perfectly balanced and therefore the nulls may not be complete. For the same reason, the nulls may not be perpendicular to the direction of maximum signal.

The box antenna exacerbates these problems. This shortcoming is related to the fact that the antenna has a width equivalent to "n" turns. As a result, the box loop acts as if it is two loops—the one you see plus a second, smaller loop perpendicular to the real loop.

You can, to a degree, counter these effects in two ways. First, keep the adjacent turns of the winding closely spaced so the width of the winding is small. This creates a secondary problem, however. Decreasing the spacing increases the capacitance between turns. To offset this effect, use small-diameter wire. (I use #26 enameled wire.) Second, reduce the number of turns in the antenna. As you reduce the number of turns, you will need to increase the length of the sides to maintain the total length of the wire and the signal level.

Some fine tuning tips

Now that you have mastered the simple loop antenna and its operation, you can look into some refinements. Nighttime MW DX signals may experience some Faraday rotation, in which case the electric field of the desired incoming signal will have shifted from vertical. By mounting the loop so it can be tilted sideways (sides AB and CD tip side to side), you can maximize the signal induced in the loop by aligning the wires with the desired signal's electric field.

This gives you two movements: the first points the antenna at the station you want to peak (or null), and the second aligns the wires with the desired signal's electric field.

Notice in Figure 3 that the desired signal changes slowly (initially) as you move away from the station, but the null changes very rapidly as you vary antenna direction. For example, if you orient the antenna to eliminate an interfering signal and this puts you 20° off the desired station, you'll only lose about 6 percent of the desired signal ($\cos 0° = 1, \cos 20° = 0.94$). However, if you get greedy and try to move the antenna off a nulled station to peak the desired station, the same 20° shift will cause the nulled station to rise from no signal up to 34 percent of its maximum strength ($\cos 90° = 0$, $\cos 70° = 0.34$).

Some loops are shielded to improve their performance. The shield makes the antenna less susceptible to noise. Furthermore, the antenna can be moved from one location to another with less impact on tuning.

Some loops use pick-up coils so the antenna can be mounted away from the receiver, so the receiver need not be rotated along with the antenna, or so an amplifier can be used.

While all the loops described so far are air-wound, loops can also be wound on ferrite rods.

The simplest modification, however, is to increase the dimensions of the loop. A loop with a long base and height will require fewer turns than a smaller loop, and therefore electrical balance will be easier to maintain. As a result, the nulls will likely be deeper and they will more likely be perpendicular to the plane of the loop.

You can use loop antennas on higher frequencies, as well. For example, I used the same design to build a loop for the tropical bands. My prototype loop used six turns on the same size frame as the MW loop described previously. The one design modification I had to make was to wind a one-turn pick-up winding beside the loop antenna to couple the loop to the receiver's antenna input.

My first attempt at reception started at 0200 UTC. I aimed the loop toward Ottawa to hear CHU (the Canadian time station). The 3 kW signal on 3330 kHz from the station located 195 miles away was strong. Somewhat weaker, but still readable, was WWV (2500 kHz with 2.5 kW) located 1350 miles to the west in Fort Collins, Colorado. Now, full of enthusiasm, I tuned to 3995 kHz. Deutsche Welle's broadcast aimed at Europe was full-strength.

At 0325 UTC, I was preparing to listen for the BBC's broadcast on 3955 kHz. Rather than the silence I expected to hear, I heard Channel Africa from Johannesburg, South Africa, signing on! And then at 0400 UTC, the BBC came in—weaker than Channel Africa, but readable. In one last test of the loop, I tuned to 3965 kHz to log Radio France Internationale's 4 kW European broadcast. The signal was extremely weak and almost at the noise level, but I eventually managed a positive ID.

My next project (the following night) was a loop for the 49-meter band. Results were not as spectacular as the previous night's effort, but the loop consistently outperformed the receiver's built-in telescoping whip.

Whether you opt for a simple, small loop or a large one that you can tilt and rotate, you're sure to hear a fascinating variety of MW (and higher frequency) stations.

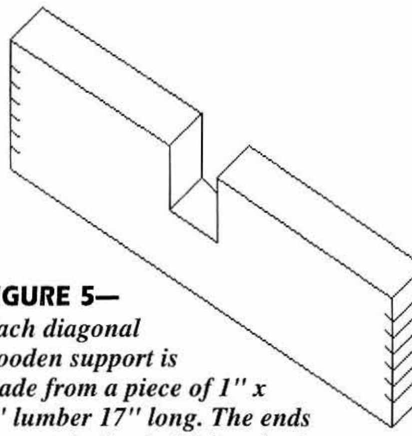
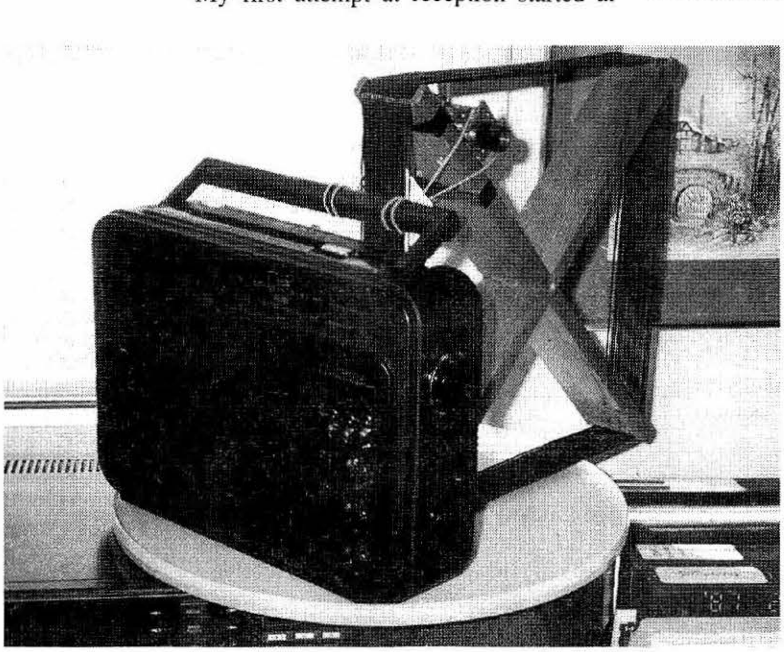


FIGURE 5— ***Each diagonal wooden support is made from a piece of 1" x 4" lumber 17" long. The ends are notched to hold the wire in place. Each support is cut halfway through at the center to allow the two supports to interlock. They can then be glued in place.***



The finished product, mounted to author's radio.